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CHARACTERISTICS OF THE COURSE OF COMBINED AFFECTIONS CAUSED BY THE ACTION OF IONIZING RADIATION AND BURN TRAUMA

[This is a translation of an article written by A. L. Komendantova, and others in Meditinskaya Radiologiya (Medical Radiology), Vol IV, No 10, 1959, pages 54-58.]

A large number of investigations by foreign as well as Soviet authors have been devoted to the study of the mutually aggravating effect of burns and ionizing radiation in combined affections (A. N. Berkutov, B. M. Khromov, V. A. Polyakov, A. S. Rovnov, Brooks, Evans, Ham and Reid, Alpen and Sheline, Baxter, Drummond, Newshaam and Raudel, M. Black and M. Tsuzuki Kusano, et al.). The physiological mechanisms of the mutually aggravating symptom in combined affections are obscure. It is generally believed that infection is basic to its development. This symptom is, first of all, a function of the radiation dose and the severity of the burn trauma in combined affections, caused by the effect of the burn and the ionizing radiation. However, its development depends on a number of conditions: the initial state of the organism, its individual sensitivity to the action of ionizing radiation, the immunobiological reactivity level, the state of the hemopoietic system, the type of therapy, etc.

In the present report we presented the experimental data which characterize the course of combined affections caused by the action of ionizing radiation in doses of 400-600 r, coupled with first-second and second-third degree burns covering from 1.5 to 10 percent of the body surface of dogs. The burns were inflicted by means of a magnesium flash, i.e., a source of heat energy of high intensity and brief action. Magnesium mixed with barium peroxide was ignited at a distance of one centimeter (second-third degree burns) and 8-10 cm (first-second degree burns) from the skin of the animal.

Burns caused by powerful sources of heat energy of brief action have their pathogenetic characteristics (Pearse and Payne). While in moderate heat (burns from a flame, or from boiling water), we observe gradual extension in the degree of tissue injury between the normal and damaged

tissues, from the center of the injury to its periphery, in burns caused by a "flash" this gradualness is absent. There is a distinct demarcation between the normal and the damaged tissues. In these cases there is usually a charring of the tissues in the center, a zone of white coagulation on the periphery, and a narrow hyperrhemic line which surrounds the entire affected zone. In less severe burns zones of white-coagulation necrosis appear predominantly, and in certain areas change into a solid crust of brown color. Edema and erythema are quite frequently present. Healing is effected mainly through sequestration. Epitholization develops with more intensity than it does in usual burns. This is due to the fact that the epithelium is developing from non-damaged epithelial elements along the periphery of the burn and skin appendages. Severe burns caused by a radiation flash, as compared to burns caused by a moderate heat action (boiling water, steam, flame), also healed faster and were accompanied by a lower mortality rate.

The added effect of ionizing radiation aggravated the course of these burns in the majority of cases.

In our experiments, treatment of the animals started within 24 hours following the infliction of the combined trauma. It was conducted in accordance with the scheme worked out by P. D. Gorizontov. We made a substantial change in this scheme: the transfusion of its derivatives was replaced by the intravenous administration of Belen'kiy's therapeutic serum. This serum possesses anaphylactogenic properties. However, if this serum is administered to animals with combined affections at intervals of 1-1 days, the number of complications does not exceed 3.6 percent. The complications develop, as a rule, after the sixth or seventh administration of the serum, and coincide in time with the height of the radiation sickness.

In the first control series of experiments on dogs, we studied the effect of small second-third degree burns, of two to five percent of body surface, on the course of the radiation sickness induced by a 400 r dose of ionizing radiation. No therapy was employed in this series. A total of 13 dogs perished in this experiment. The mortality rate was 92 percent. The average life span was 14 days.

According to the data of P. D. Gorizontov, the mortality rate of non-treated animals subjected to ionizing radiation of 400 r is 20 percent. The life span does not exceed 20 days. The mortality rate of dogs with third degree burns, of five percent body surface, with no ionizing radiation complications is nil.

The aggravating effect of small second-third degree

burns on the course of a radiation trauma manifested itself in a higher percentage of mortality in the animals, a shortening of their life span, a more acute course of the radiation sickness, development of a hemorrhagic syndrome at an early stage following the combined action, a reduction of the blood proteins, increase of the residual nitrogen, and a distinct leukopenia and thrombopenia. Changes in the composition of the red blood cells were insignificant up to the 10th to the 14th day. Two animals which had perished on the 24th-26th day showed a reduction of the number of blood erythrocytes (from 5,240,000 to 3,150,000 on the average), and of the Hb percentage)from 85 to 46 percent on the average). The body temperature of the animals usually increased to 41°C and higher just before death; loss of weight was 25-30 percent during the ten-day period.

The high mortality rate of these animals demonstrated the markedly aggravating effect that very small second-third degree burns (1.5 to five percent of the body surface) exert on the course of radiation sickness brought on by a 400 r dose of ionizing radiation.

In the subsequent series of our investigations we studied the effect of a burn and ionizing radiation on the animal organism under conditions of complex therapy. At the same time, we studied the characteristics of the course of combined affections when ionizing radiation was combined with second and third degree burns, and with some smaller first and second degree burns. A total of 27 dogs was exposed to the effect of a 400 r dose of ionizing radiation combined with burns of 1.5 to 10 percent of body surface. Of these, seven perished. The mortality rate was 25.9 percent.

Small superficial first and second degree burns were inflicted on six dogs which had been previously irradiated with a 400 r dose. The animsls survived, which had radiation injuries complicated by first-second degree burns of 10 percent of body surface. Their sickness had a clinically mind course. It manifested itself in slight lassitude, a thin, gruel-like stool, and a slight rise in body temperature on the 8th-12th day following the injury. The blood proteins fluctuated within normal limits, the weight remaining stationary or even rising. Of 14 dogs with second-third degree burns of five percent of body surface, combined with the effect of a 400 r dose of ionizing radiation, nine perished. With an increase of the burned area from five to 10 percent, the mortality rate rose to 55 percent (four dogs out of seven perished.) The clinical course of the sickness in animals with a combined affection caused by

exposure to ionizing radiation and second-third degree burns of five percent of the body surface was the same as in control animals with a non-complicated radiation sickness. The amount of blood proteins in the animals which had survived varied within normal limits, and the residual N of the blood did not rise. The weight of the animals was somewhat lower.

Upon an increase of the burned area, the disease ran a more severe course; correspondingly, the mortality rate was markedly higher. The epithelization of the first-second degree burns was completed toward the end of the month, while that of the second-third degree burns lasted between two to three months. In some animals it took longer; at times, non-healing protracted wounds, filled with sluggish, sclerozed granulations at the site of the burn. These ulcers would grow in size periodically.

The changes in the peripheral blood of the experimental animals and controls with a non-complicated radiation trauma developed according to uniform laws. However, in the development of these changes certain characteristics were elicited which were connected with the effect of burns of diverse severity (see Table). We observed in burns combined with the effect of a 400 r ionizing radiation dose (in treated animals) a slower reduction, after an initial rise, of the number of leucocytes in the peripheral blood, as compared to their change in animals with a non-complicated radiation trauma. At this, a wave-like character of the changes in the quantity of leucocytes of the blood was noted, which can be connected with the presence of directly opposed influences of the burn trauma and the ionizing radiation on the hemopoietic tissue.

In second-third degree burns combined with the effect of a 400 r dose of ionizing radiation, the number of leucocytes in the peripheral blood is reduced to the leucocytary curve-level of the control animals with non-complicated radiation affections. Slight burns combined with radiation traumas retarded the development of leukopenia to a certain extent. The rise in the number of leucocytes starts on the 17th-19th day and develops more intensively in animals subjected to the effect of the radiation trauma combined with a burn.

The lymphocytes of animals subjected to a 400 r radiation and a slight burn trauma increase in number during the first few days. There is no initial increase observed in their number in animals with radiation affections combined with second-third degree burns. The rise in the number of lymphocytes began in both groups of animals on the

13th-14th day. The content of erythrocytes in animals with combined affections under conditions of treatment is reduced to a lesser degree than in the control animals with a non-complicated radiation trauma.

The data of this series of studies demonstrated the lessening of the mutually aggravating effect of a burn trauma combined with ionizing radiation, when complex therapy was employed. Under these circumstances, second degree burns involving 10 percent of body surface do not exert an aggravating effect on the course of the radiation affection, and inhibit somewhat the development of leukopenia. Otherwise, a high mortality rate is observed when radiation trauma is combined with second-third degree burns involving 10-percent of the body surface.

In the third series of experiments, involving 22 dogs, we studied the effect of first-second and second-third degree burn trauma over an area of 2.5 to five percent of the body surface, on the course of radiation sickness caused by a 600 r dose of ionizing radiation. In these experiments the treatment also began within 24 hours following the infliction of a burn trauma. A total of 95 percent of non-treated animals with a non-complicated radiation trauma of a 600 r dose perished, according to data of P. D. Gorizontov. The average life span of these animals does not exceed 13 days. Under conditions of the treatment employed by us, of nine animals irradiated with a 600 r dose one died. The mortality rate was 11 percent.

The addition of slight second-third degree burns to the action of ionizing radiation reduces the effect of treatment of the radiation trauma to zero. All animals perished in spite of the treatment. The average span life did not exceed 14 days.

The majority of animals with radiation traumas complicated by slight burns)first-second degree) of five percent body surface survived under conditions of treatment. Clinically, the affection in these animals had a course similar to the one of control animals with a non-complicated radiation trauma caused by 600 r of ionizing radiation; a slight loss of weight was observed in a number of animals, and the protein content was slightly reduced. There was no marked accretion of the residual N in the blood.

Under the effect of the addition of second-third degree burns of five percent of body surface to the action of ionizing radiation, the sickness took a very severe turn starting on the fourth-fifth day. The animals refused food and became listless; a bloody diarrhea and a hemorrhagic nasal discharge appeared. In a number of animals petechial

hemorrhages in the skin and oral mucosa were observed. The blood protein content decreased, and that of the residual N was higher. The leucocyte count of the blood was lower in the majority of dogs immediately after the trauma. It decreased more drastically, starting on the seventh day, in the blood of dogs subjected to the action of ionizing radiation combined with second-third degree burns.

In animals with mild burns combined with a 600 r dose of ionizing radiation, the leucocyte content was reduced to a somewhat lower extent than in the control animals with a non-complicated radiation sickness. The restitution of the number of leucocytes began on the third week following trauma, and it proceeded more intensively in animals with a radiation affection complicated by a slight burn. The content of lymphocytes decreased within two to four hours following trauma. Its restitution began on the 18th-24th day. The number of erythrocytes decreased to 28-30 percent of the initial level toward the 25th-30th day in the control animals, as well as in those with a radiation trauma complicated by a slight burn.

Thus, in this series, as wll, one does not observe any markedly aggravating effect of a slight burn trauma on the course of radiation sickness induced by exposure to a 600 r dose of ionizing radiation. A slight burn trauma under these conditions inhibits somewhat the decrease of leucocytes in the blood and distinctly stimulates their accretion during the initial periods of recuperation.

The addition of slight second-third degree burns of 1.5-5 percent of body surface to the radiation trauma aggravates and intensifies the course of the disease. The effect of the employed treatment decreases to zero.

Conclusions

1. Second-third degree burns of two to five percent of the body surface aggravate the course of radiation sickness caused by a 400 r dose of ionizing radiation. The mortality rate of non-treated animals is 92 percent.

2. The aggravating effect of second-third degree burns of five to ten percent of the body surface on radiation traumas caused by a 400 r dose of ionizing radiation is definitely reduced under conditions of treatment. The mortality rate does not exceed 25.9 percent.

3. Under the action of a 600 r dose of ionizing radiation the aggravating effect of second-third degree burns on the course of radiation seckness is not alleviated by treatment.

4. Mild first-second degree burns of ten percent of the body surface do not exert an aggravating influence on the course of the radiation sickness. In the process of development of the radiation sickness, the stimulating effect of the focus of infection on the hemopoietic system manifests itself, as may be seen from a certain inhibition of the development of leukopenia and an earlier and more intensive accretion of the number of leucocytes in the blood during the period of convalescence.

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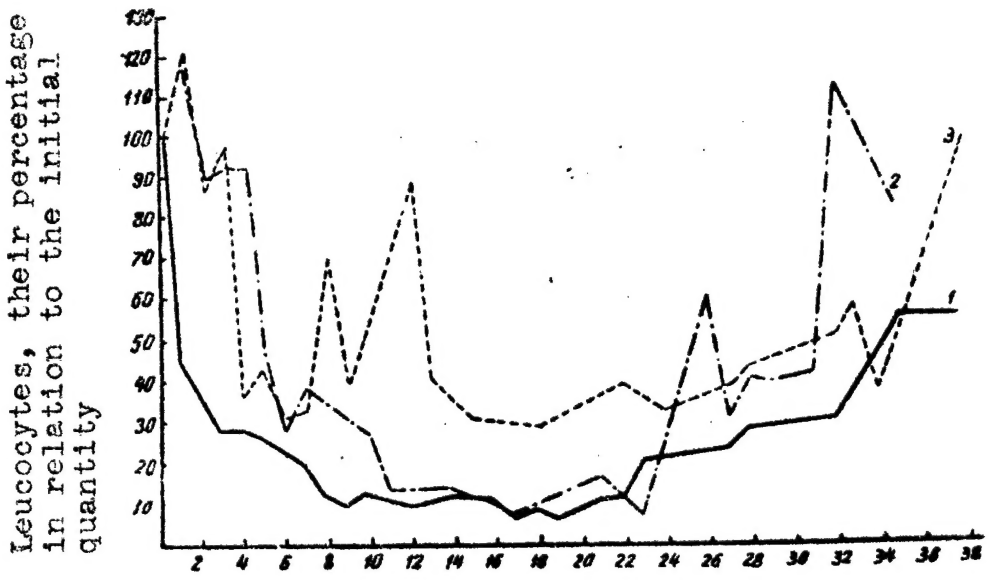

Time, Days

Dynamics of leucocytic changes in the peripheral blood of dogs which had been exposed to non-complicated 400 r dose of ionizing radiation, or to one combined with second-third and first-second degree burns.
1--ionizing radiation with a 400 r dose; 2-ionizing radiation with a burn trauma of second-third degree; 3-400 r dose combined with first-second degree burn trauma.

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